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Technical Report

R 339

ICE CONSTRUCTION — MOBILE PUMP WANIGAN FOR CONFINED FLOODING

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U. S. NAVAL CIVIL ENGINEERING LABORATORY

Port Hueneme, California

ICE CONSTRUCTION — MOBILE PUMP WANIGAN FOR CONFINED FLOODING

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Type C

by

G. E. Sherwood and E. H. Moser, Jr.

ABSTRACT

Advancements in flooding techniques for leveling and thickening natural ice areas for improved Arctic Ocean operations resulted in the development of a mobile pump wanigan for confined flooding. An extra-wide NCEL camp wanigan was outfitted for confining and distributing the flood water, for drying and storing the flooding gear, and to provide a warm shelter for the construction personnel and sufficient illumination within 300 feet for ice construction at night.

An experimental pump wanigan was evaluated at Point Barrow, Alaska, between 1958 and 1960, and selected components for the unit were evaluated at other field sites between 1960 and 1964. The mobile pump wanigan is well suited for thickening sea ice by confined flooding and is recommended as standard equipment for this type of ice construction. Specifications, reduced scale drawings, and commercial items were published in Technical Note N-608. Erection instructions are given in Technical Note N-587.

INTRODUCTION

Activity on the ice-covered Arctic Ocean has increased rapidly in recent years. Ice islands (old tabular icebergs) have been used as year-round floating scientific stations; smooth natural sea-ice areas have been used periodically for field observations and limited aircraft landings. Both types of areas are scarce and, in their natural state, they are suitable only for pioneer operations. Ice islands usually have rolling, highly dissected surfaces; smooth sea ice areas are limited in size and thickness.

Investigations have shown that natural ice can be leveled and thickened by surface flooding in below-freezing temperatures. The surface is flooded in increments and allowed to freeze between floodings. Two flooding techniques have been developed by NCEL: (1) confined flooding, where the flood is retained by natural boundaries and dikes, and (2) free flooding, where the spread of the flood is limited only by its rate and volume and the prevailing temperature and wind.

This report covers the development of a mobile pump wanigan for confined flooding. It is outfitted with equipment and gear for controlled distribution of the flood water. Also, it provides a heated area for warm-up and protection of personnel at the construction site and for thawing and drying the flooding gear.

Background

The thickening of natural sea ice by surface flooding was first investigated by NCEL on the Arctic Ocean near Point Barrow, Alaska, in the winters of 1950-51 and 1951-52. The pumping equipment, hose, and other gear for flooding the ice were housed in a field-fabricated structure mounted on a go-devil sled. The trials were resumed in the winter of 1958-59.[1] For these trials, an experimental, self-contained, mobile pumping unit was designed and outfitted for controlled delivery of the flood water.

Many features in the experimental pumping unit were derived from the 1950-52 effort; others were added to improve its performance. A slightly modified extra-wide NCEL camp wanigan[2] was used to house the pumping equipment and flooding gear. This permitted complete disassembly of the unit for air shipment to the field site, and, once there, the unit could be moved by tractor without being mounted on a sled. The wanigan was outfitted with pumps, a variety of hose and fittings, storage racks, and other accessories.

During the 1958-59 trials[1] in temperatures from 20 to -44 F, the mobile wanigan was used in building several confined test plots and one free flood plot. It was generally satisfactory for confined flooding, but not for free flooding because the area occupied by the wanigan had to be diked to prevent its being inundated by the flood water. In tow tests with a Size 1 snow tractor, the wanigan was easily moved over snow, ice, and permafrost. The trials showed that some changes in outfitting would improve performance.[3]

Additional tests were made on the experimental pump wanigan in the 1959-60 Point Barrow trials.[4] Alternate components and accessories were selected and evaluated at various field sites between 1960 and 1963.

Criteria

Confined flooding requires pumps, hoses, fittings, and other assorted equipment to lift, move, distribute, and confine flood water. Shelter is required to house the pumps, dry the hoses, thaw the fittings, and protect the construction personnel. The package must be a self-contained mobile unit capable of performing all functions of moving and spreading sea water in air temperatures to -40 F. Based on these requirements, the following criteria were developed for the pump wanigan:

1. A mobile shelter, with adequate heating and lighting, to house the pumping equipment and flooding gear
2. A stationary diesel-driven pump
3. Hand-carry pumps
4. Suction and discharge hose
5. A means for storing and drying the hose and fittings
6. Portable electrical power
7. Floodlights

DESCRIPTION

Components for the pump wanigan (Figures 1 and 2) were selected for general use in confined flooding. They included a wanigan, a stationary pump, two hand-carry pumps, suction and distribution hose, hose fittings, storage racks, two portable electrical generators, a heating and ventilating system, an electrical harness, and floodlights. For special applications, the pumps and hose can be varied to meet specific requirements. The estimated cost, shipping weight, and cube of the selected components are given in Table I. Based on 1962 prices, the total cost of the pump wanigan is $20,000. Packaged for shipment, it weighs 16,000 pounds and occupies 850 cubic feet.

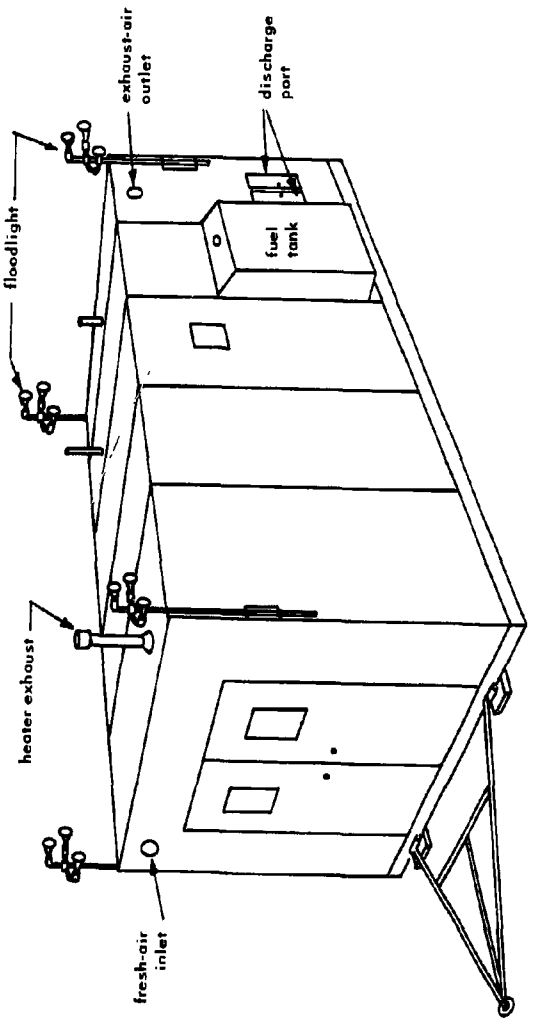

Figure 1. Schematic of the pump wanigan.

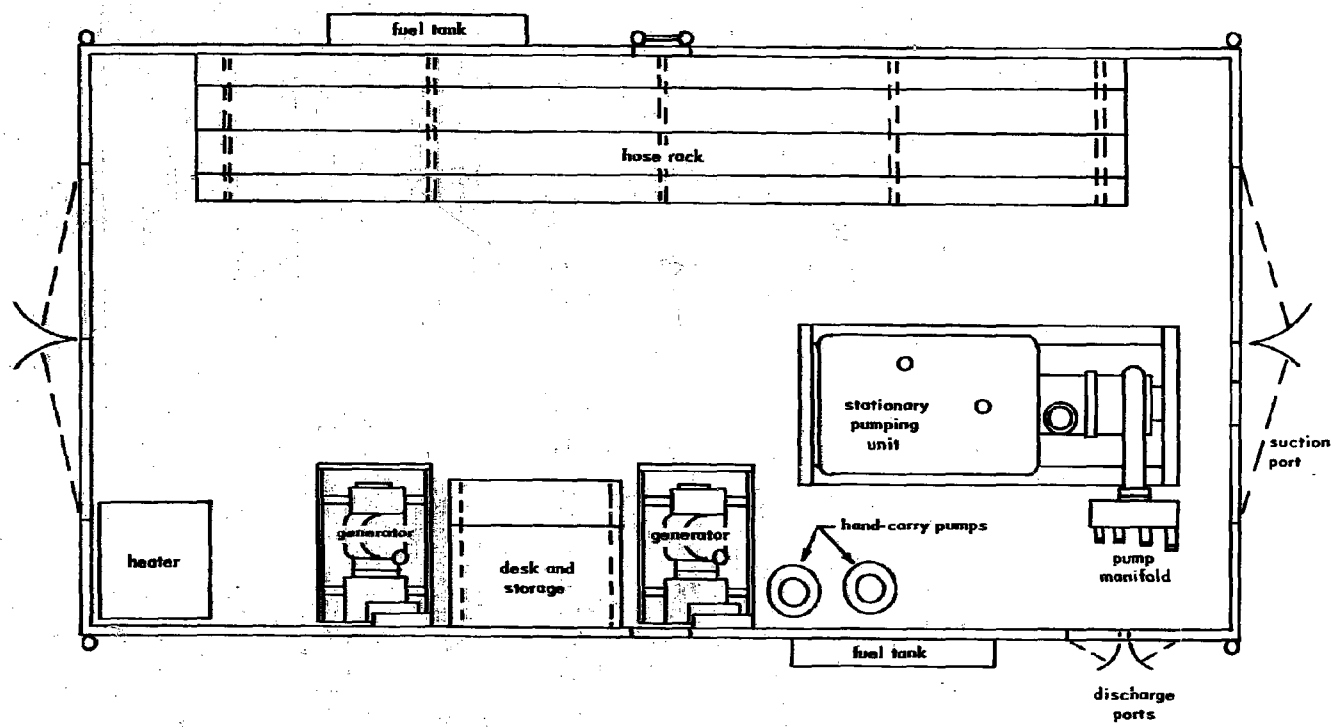

Figure 2. Layout of pump wanigan.

Table I. Weight, Cube, and Cost of Pump Wanigan Components

Component	Quantity	Shipping Weight (lb)	Cube (ft^3)	Cost ($)
Wanigan outfitted with accessories and modified with hose ports	1	7,160	430	7,050
Stationary pump	1	5,118	160	7,550
Hand-carry pumps	2	60	2	600
Hose and fittings	1/	2,000	108	3,000
Hose rack and desk	1	1,172	104	400
Electrical generators	2	320	30	1,100
Extra fuel tank for gasoline	1	170	16	300
TOTAL		16,000	850	20,000

1/ See Table II

A schedule of drawings for the pump wanigan is given in the Appendix. Copies of these drawings are available from the Naval Civil Engineering Laboratory. Specifications, commercial items, and reduced scale drawings for fabricating and outfitting the pump wanigan are listed in Technical Note N-608.[5] Erection details for the wanigan are given in Technical Note N-587.[6]

Wanigan

A modified extra-wide NCEL camp wanigan[2] houses the pumping equipment and other components. It is mounted on skids and fitted with a drawbar for portability. With the drawbar, the pump wanigan (Figure 1) is 26 feet long, 10 feet wide, and 8 feet 9-7/8 inches high. The shelter (Figure 2) is 20 feet long, 10 feet wide, and 8 feet high. It is constructed of insulated wood frame and plywood panels bolted together through gasketed lap joints. The wall panels are bolted to a heavy-duty skid-mounted floor.

The wanigan was modified to provide suction and discharge ports for the stationary pump. A special wall panel with a small double door was used for the discharge hose. It is located in the sidewall directly in front of the pump manifold (Figure 2). A special door panel with a small insert door was used for the suction hose. It is located in the endwall directly in front of the pump.

Stationary Pump

The stationary pump (Figure 3) is a diesel-driven, single-stage, horizontal, centrifugal unit with a bronze impeller and an engine exhaust primer on the pressure side. It is bolted to a pump base attached to the floor of the wanigan near the rear doors.

When operating at 1,800 rpm, the pump delivers 1,000 gpm at 150-foot head with 74 percent efficiency, and 1,400 gpm at 100-foot head with 55 percent efficiency. It is fitted with a 5-inch flange for suction and a 4-inch flange for discharge. A special manifold (Figure 4) is bolted to the discharge flange to distribute the flood water. It has four threaded discharge ports fitted with 2-1/2-inch ball valves.

The pump is quill-mounted through a disk-type clutch to a four-cycle, four-cylinder diesel engine rated at 48 hp at 1,800 rpm. The engine is fitted with a 24-volt starter and a gasoline starting engine.

Hand-Carry Pumps

Two identical, electrically driven, hand-carry, submersible pumps (Figure 5) are included in the outfitting. When not in use, they are stored near the stationary pump. These pumps are 1-hp, single-phase, 115/220-volt units which can be used separately or in tandem. The capacity of one pump is 120 gpm at a 10-foot head; the capacity of the two pumps in tandem is 140 gpm at a 10-foot head and 120 gpm at a 22-foot head. Each pump weighs 21 pounds and requires 2 kw for starting.

Hose and Fittings

The discharge hose is standard, black carbolized, neoprene-covered fire hose. Twenty-four 50-foot sections and six 16-foot sections of 2-1/2-inch discharge hose and three 10-foot lengths of 5-inch, rubber-covered suction hose are provided for the stationary pump. Five 50-foot sections of 1-1/2-inch hose are provided for the portable pumps. The hose fittings include strainers, hose caps, aluminum quick couplings, and gaskets. The type, size, and quantity of hose and fittings are listed in Table II.

Table II. Hose and Fittings

Item	Type	Length (ft)	Diameter (in.)	Quantity
Hose	Discharge, standard black carbolized neoprene-covered fire hose	16	2-1/2	6
		50	2-1/2	24
		50	1-1/2	5
	Suction, semiflexible, rubber-covered (fire-engine type)	10	5	3
Aluminum Quick Couplings (spares)	Adaptor, male coupling to male pipe thread		5	1
			2-1/2	2
			1-1/2	2
	Adaptor, female coupling to male pipe thread		2-1/2	2
	Female shank hose coupling		2-1/2	2
			1-1/2	2
	Male shank hose coupling		2-1/2	2
			1-1/2	2
Gaskets	Quick coupling, buna S composition		5	2
			2-1/2	15
			1-1/2	2
Hose Cap	Aluminum quick coupling		2-1/2	4
			1-1/2	2
Strainer	Suction hose		5	1

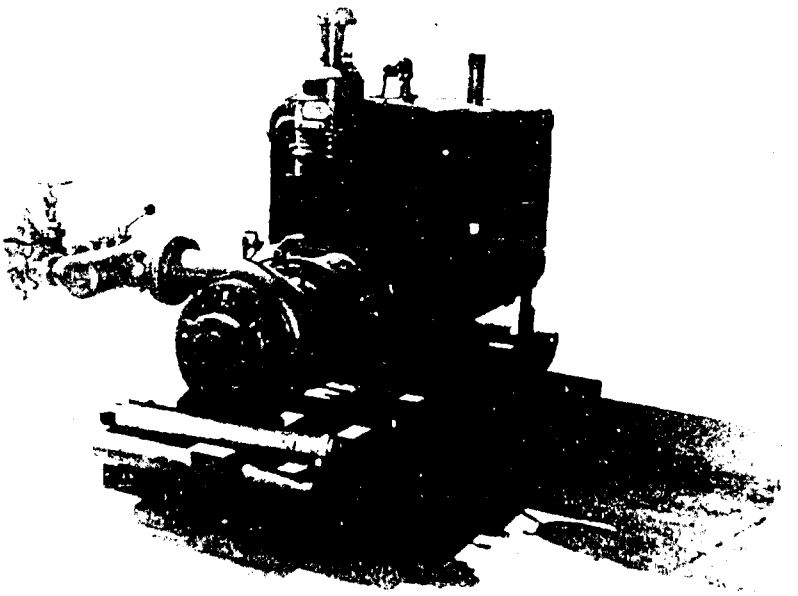

Figure 3. Stationary pump.

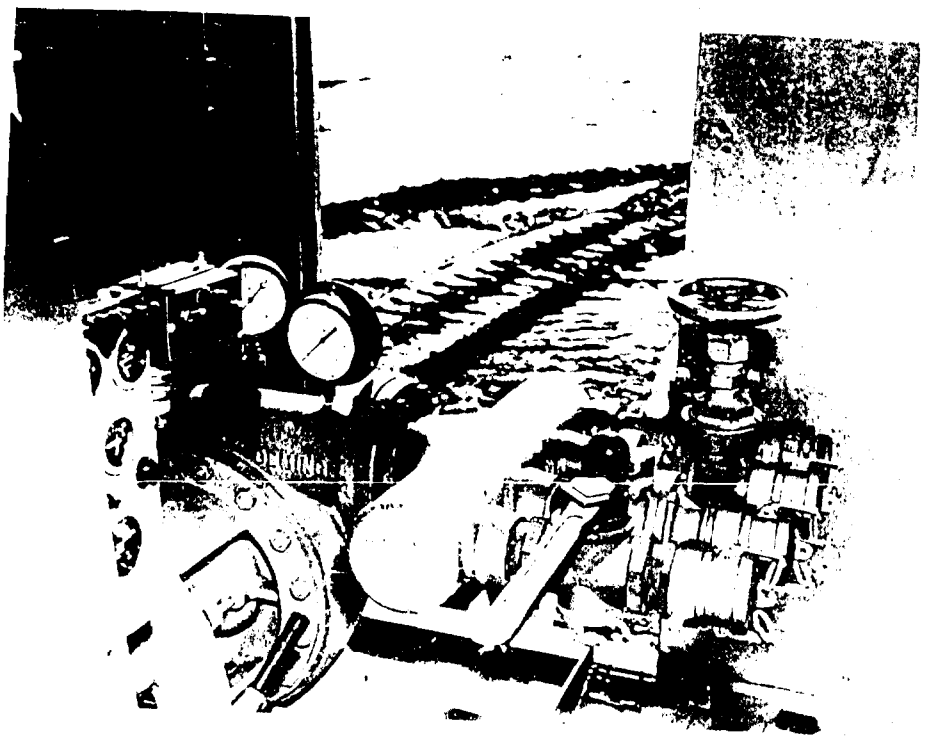

Figure 4. Stationary pump discharge manifold.

Figure 5. Hand-carry submersible pump.

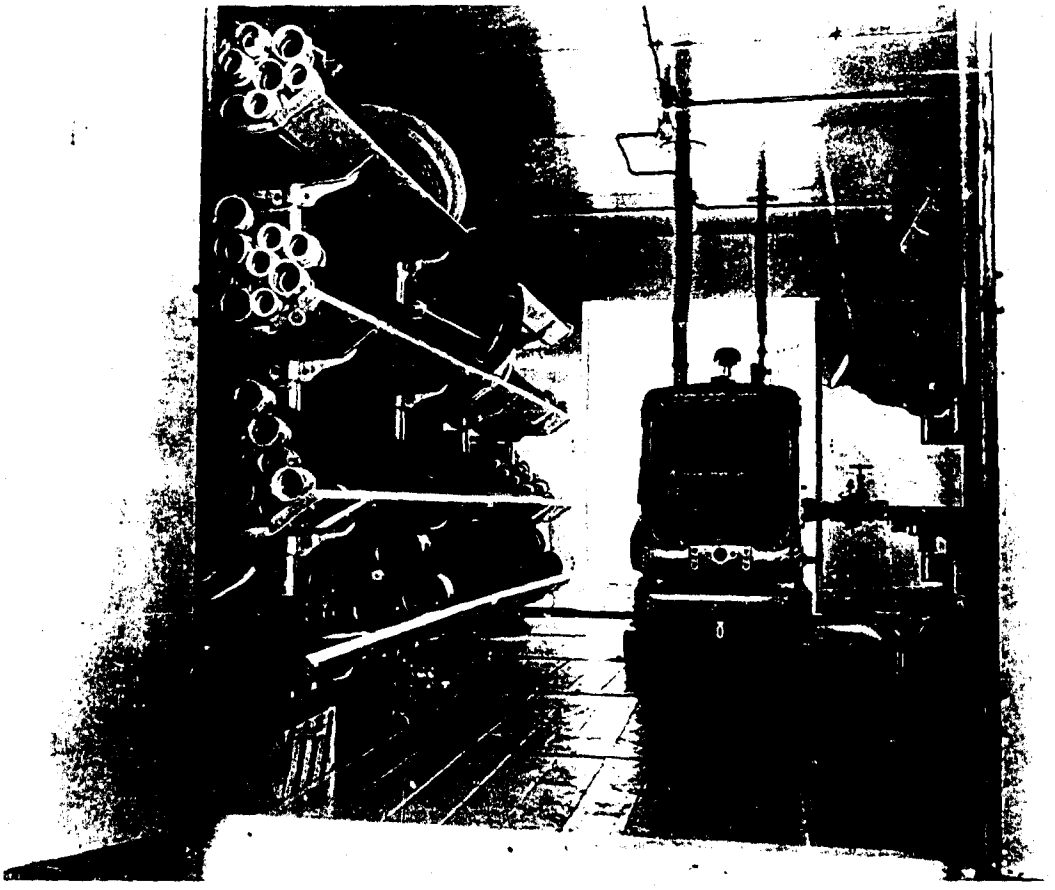

Figure 6. Hose rack in the experimental pump wanigan.

Storage Racks

The hose is stored in a three-tier rack along one side of the wanigan (Figure 6). The rack consists of aluminum stanchions connected with wooden strips to form three 16-foot-long trains. The 50-foot lengths of hose are rolled and stacked side by side on the top tray. The 16- and 10-foot lengths of hose are stored flat on the bottom trays and are secured with tie-down straps.

A 3-1 2-foot combination desk and three-tier storage unit is opposite the hose rack near the entrance (Figure 7). It is also constructed with aluminum stanchions. The storage tiers are fitted with metal trays for the hose fittings.

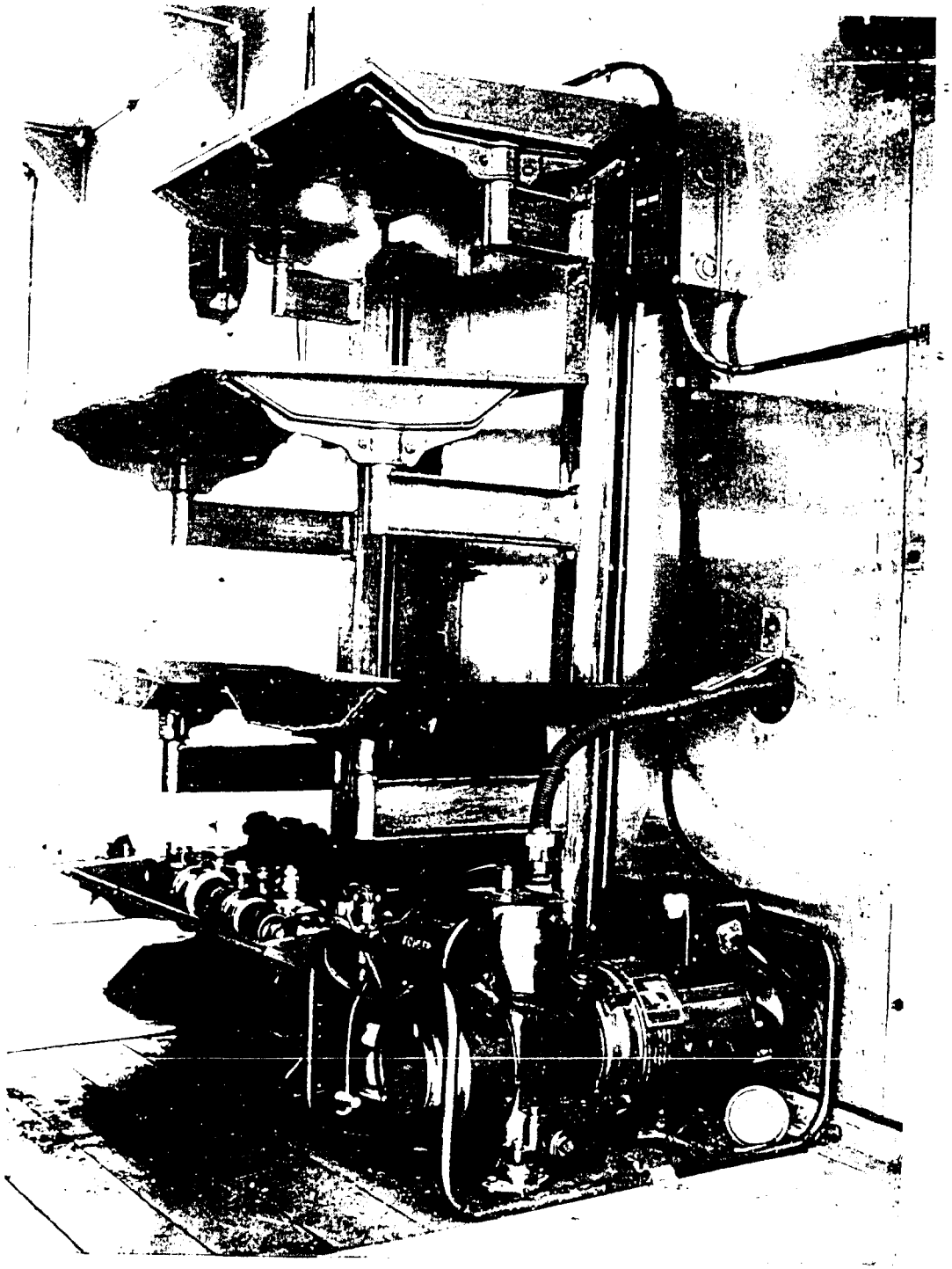

Figure 7. Desk and storage unit.

Portable Electrical Generators

Two identical portable electric generators are included in the outfitting (Figure 7). One provides power for the wanigan and the other drives the submersible pumps. When not in use, the generators are stored next to the desk/storage unit. Each is a 2.5-kw, 115/230-volt, 60-cycle, single-phase unit driven by single-cylinder, four-cycle, air-cooled gasoline engines rated at 6.6 hp at 3,600 rpm. The generators weigh 158 pounds each.

Accessories

The standard NCEL wanigan heating and ventilating system and electrical harness[2] are used in the pump wanigan. The heater is a 25,000 Btuh, commercial mobile-home-type diesel unit, serviced by an 80-gallon, side-mounted fuel tank which also supplies fuel to the diesel-driven stationary pump. The ventilation system consists of 60-cfm, wall-mounted intake- and exhaust-air fixtures at opposite ends of the wanigan (Figure 1). The electrical harness provides for general interior lighting and for interior and exterior power outlets.

Other accessories for the pump wanigan are a second 80-gallon, side-mounted fuel tank for the gasoline-driven generators, and a three-bulb cluster floodlight at each corner of the wanigan (Figure 1). For vertical adjustment, the floodlights are mounted on 2-inch aluminum pipes which slide into 2-1/2-inch aluminum pipe brackets. The brackets are bolted to the wanigan.

PERFORMANCE

The 10-foot width of the pump wanigan prohibits its air-shipment as an assembled unit in a C-130, but assembly at the field site is not difficult. The wanigan can be erected in temperatures to 10 F in about 31 manhours,[2] and the outfitting can be installed in about 16 manhours. All parts and pieces can be handled by two men except the wanigan skids and the stationary pump.

In the 1958-59 and 1959-60 Point Barrow trials,[3,4] the experimental pump wanigan (Figure 8) was used extensively for confined flooding. Its interior arrangement, similar to the packaged pump wanigan (Figure 2), was convenient and efficient for operating the stationary pump, maintaining the hose and fitting, and making minor repairs to the flooding gear. The double doors in the endwalls permitted easy access for the hose, the hand-carry pumps, and the generator. The suction and discharge ports simplified the hookup of the hose (Figure 9) and they minimized the infiltration of weather when pumping.

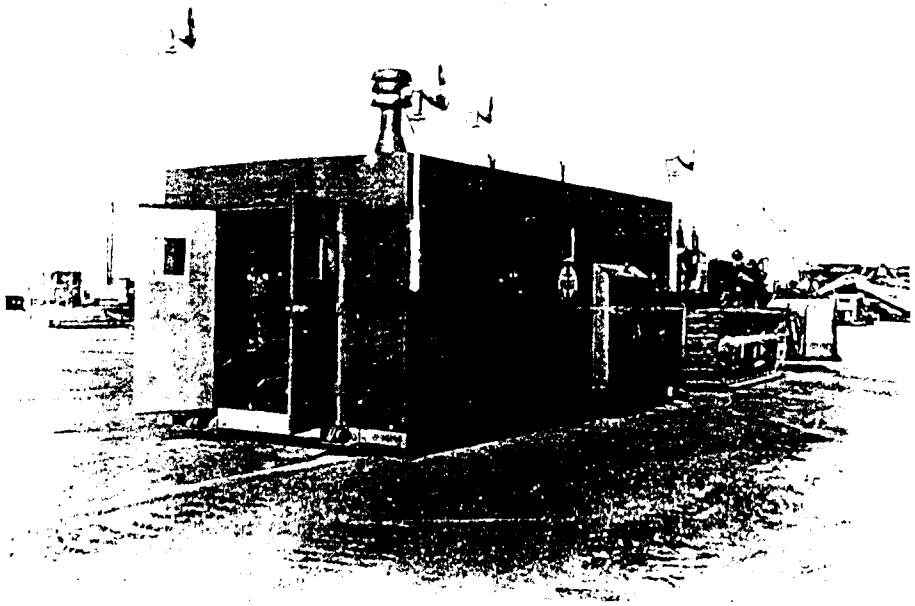

Figure 8. Experimental pump wanigan.

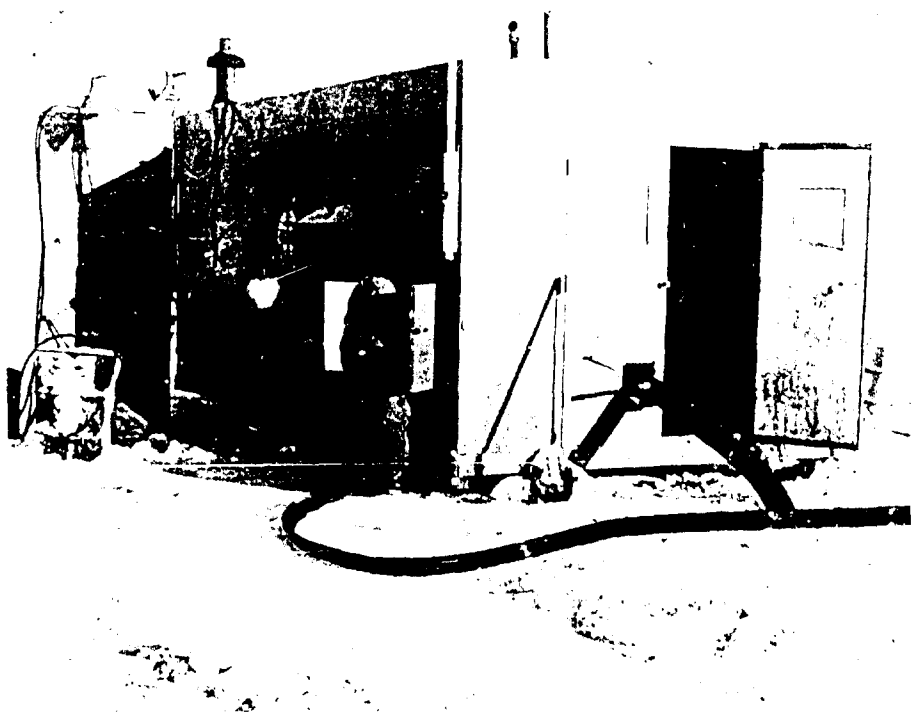

Figure 9. Hooking discharge hose to stationary pump in experimental pump wanigan.

The 1,000-gpm stationary pump for the packaged unit was selected for general service in confined flooding. Its selection was based on the performance of the prototype pump in the experimental unit.[3] A larger pump can be used for special applications, provided its size and weight do not exceed the space and allowable floor load of 2,500 pounds for each 4-foot bay in the wanigan.

The prototype of the stationary pump was used for 2 months during the 1958-59 trials. It pumped about 5,000,000 gallons of sea water onto confined test plots up to 300 feet in diameter (Figure 10) in temperatures between 20 and -44 F. Because of the sequence and flooding increments for the experimental tests, it was seldom possible to use more than one 250-gpm discharge hose at a time when flooding the small plots (Figure 11). Four hose lines (Figure 12) could be used simultaneously to flood the 300-foot circular plot. This not only resulted in better control and distribution of the flood, but also allowed the pump to work near its rated capacity.

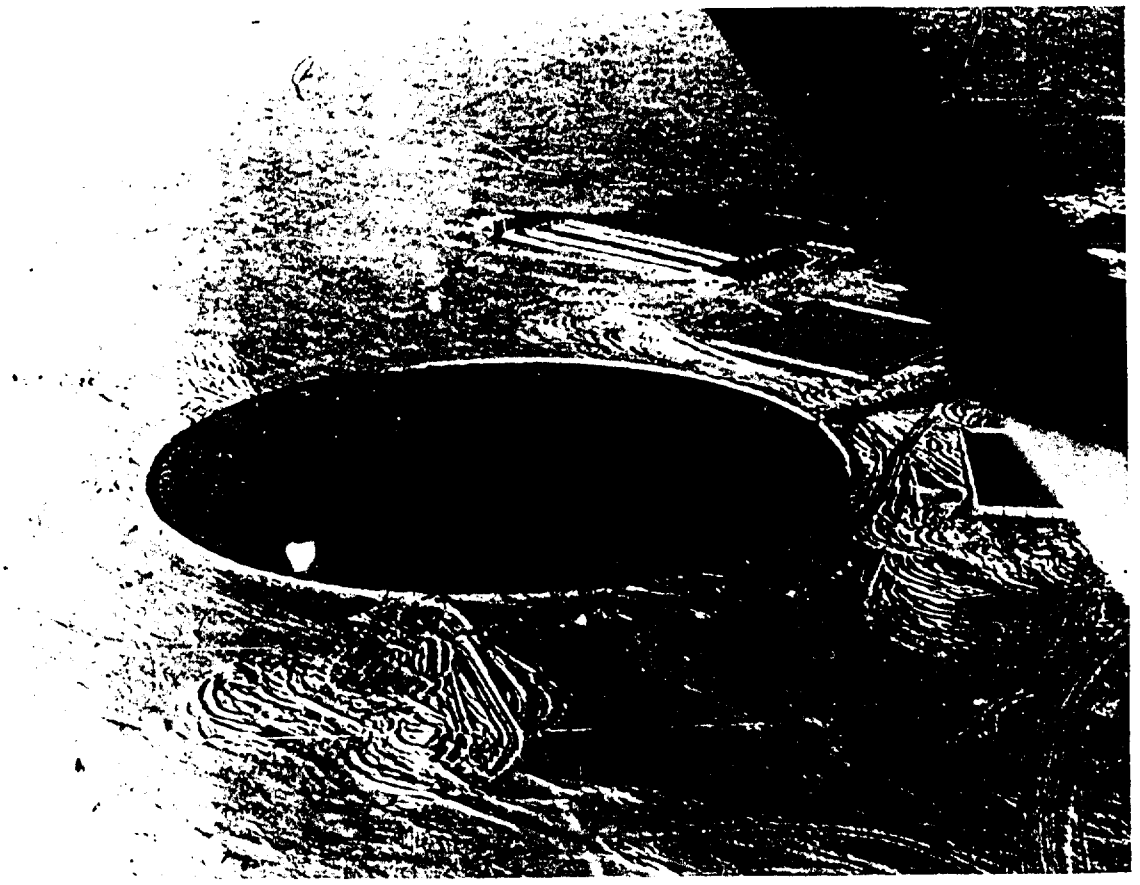

Figure 10. Confined 300-foot-diameter test plot built in 1958-59 Point Barrow trials.

Figure 11. Using single 2-1/2-inch hose line to flood 100-foot-square test plot.

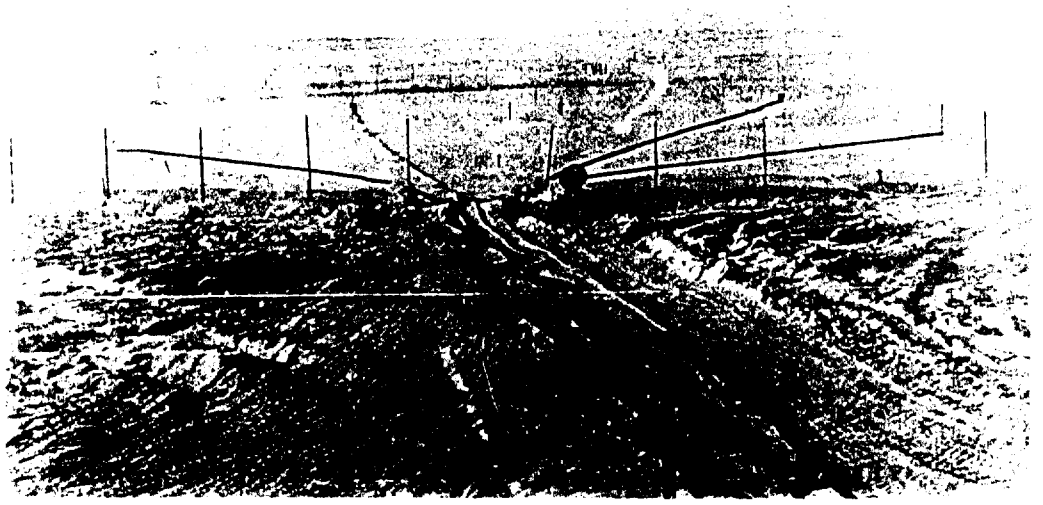

Figure 12. Using four 2-1/2-inch hose lines to flood 300-foot-diameter test plot.

The pump was easy to start and operate in the heated wanigan. No cold starts were required and the pump was never operated under cold conditions. Oil consumption on the pump engine was high; it increased to 5 quarts for each 9 hours of operation after 2 months of use. This was attributed to inadequate break-in of the engine and light pumping in the trials. Normal priming time for the pump ranged from 20 to 60 seconds, the average operating pressure was between 60 and 70 psi, and the pump vacuum was 5 psi. Difficulties with the pump were minor and easily corrected. There was some leakage around the packing glands, and occasionally the priming line froze.

The 120-gpm, electrically driven submersible pumps for the packaged wanigan were selected for one-man use in constructing artificial dikes and sealing natural dikes for confined flooding and in maintaining and repairing damaged ice areas. A prototype of this pump was evaluated by the Laboratory during ablation studies on sea ice at Point Barrow, Alaska, in the spring of 1962.[7] In comparison with the hand-carry, 130-gpm, gasoline-driven pump, which was evaluated in the 1958-59 trials,[3] it was easier to handle, easier to start, and it did not require priming. Its pumping capabilities were equal to those of the gasoline-driven pump.

In special applications where a large number of hand-carry pumps are required, the gasoline-driven surface pump can be substituted for the electrically driven submersible pump to reduce the electrical requirements for this type of pumping. The 130-gpm, gasoline-driven pump is a single-stage, horizontal, centrifugal, self-priming unit with a cast-iron impeller. It is fitted with 2-inch ports for suction and discharge. The pump is quill-coupled to an air-cooled, four-cycle, single-cylinder gasoline engine rated at 2.76 hp at 3,600 rpm. The pump, which is mounted on skids, weighs 70 pounds.

Standard, black carbolized, neoprene-covered discharge hose was selected for the packaged wanigan. It was superior to the other types tested with the experimental unit;[3] it retained enough flexibility at low temperatures for easy handling, yet it had just enough built-in rigidity to hold its shape when laid flat. In the trials, 50-foot lengths of this hose could be rolled for handling and storage, and they were easy to lay and recover. Twelve hundred feet of 2-1/2-inch discharge hose in 50-foot lengths are supplied with the packaged pump wanigan. This provides 300 feet of hose for each discharge port on the stationary pump. In addition, six 16-foot lengths of 2-1/2-inch hose are included for adjusting the distribution of the flood. This hose is stored flat. To provide some flexibility of location, 30 feet of 5-inch rubber-covered suction hose in 10-foot lengths is included for the stationary pump. This hose is easy to carry draped over the shoulder; it is stored flat. Two hundred and fifty feet of 1-1/2-inch discharge hose in 50-foot lengths is included for the hand-carry electrically driven submersible pumps. It was found that this is about the maximum practical length of hose for this pump. This hose is rolled for handling and storage.

Aluminum quick couplings were selected for the hose. In the trials, they were much easier to use in making up and recovering hose lines than were brass couplings with standard fire hose threads. The aluminum quick couplings were faster to assemble and, once assembled, were watertight. Ice accumulated around the quick couplings, but it was easily removed with a screwdriver or other pointed tool. The buna S composition gaskets selected for the quick couplings were satisfactory under all conditions of use, including the coupling of hose sections after cold-soaking in temperatures to -32 F.

In the packaged wanigan, the top tier on the hose rack in the experimental unit (Figure 6) was eliminated to provide sufficient storage space for the rolled hose. During the trials, it was found that the hose storage rack was convenient to use and its open construction permitted air to circulate freely around the hose. This was particularly advantageous when thawing and drying the hose.

The standard wanigan heating and ventilating system[2] used in the pump wanigan was evaluated in a similar wanigan in the antarctic between 1962 and 1964. The floodlights provide adequate illumination up to 300 feet around the wanigan for flooding operations at night.[3] The portable generators selected for the pump wanigan have been used at numerous NCEL field sites.

FINDINGS

1. The packaged mobile pump wanigan is suitable for use in leveling and thickening sea ice by confined flooding, but not by free flooding.

2. The outfitting is adequate for use in constructing dikes to confine the flood water and in delivering and controlling the distribution of the flood water.

3. The heated shelter permits normal operation of the pumping equipment, provides a heated area for thawing and drying the flooding gear, and protects the construction personnel.

4. The stationary pump and other engine-driven equipment should be properly broken in before use in the field.

5. The pumping equipment and hose can be varied within limits to satisfy specific flooding requirements.

6. The unit must be disassembled for air-shipment, but it is easily assembled in the field, and after assembly, it can easily be towed from job to job.

7. The pump wanigan weighs 16,000 pounds and occupies 850 cubic feet packaged for shipment. Based on 1962 prices, it costs $20,000.

CONCLUSIONS

The mobile pump wanigan is well suited for thickening sea ice by confined flooding and should be used as a standard piece of equipment for this type of ice construction.

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7. _____. Technical Report R-238: Point Barrow trials — FY 1962: Ablation and crystal studies of sea ice, by N. S. Stehle. Port Hueneme, Calif., April 1963.

Appendix

DRAWINGS FOR THE NCEL PUMP WANIGAN

Y&D Number	Title
	Standard NCEL Wanigan Drawings
993682	Extra-Wide Portable Wanigan Floor — Assembly
993683	Extra-Wide Portable Wanigan Floor — Skids and Cross Members
993684	Extra-Wide Portable Wanigan Floor — Frame, Panels, and Connectors
993685	Extra-Wide Portable Wanigan Floor — Tongue
993690	Wanigan Sidewall — MK-4 and MK-6 Panels
993691	Wanigan Sidewall — MK-5 Panel
993694	Extra-Wide Portable Wanigan Endwall — MK-14 and MK-17 Panels
993695	Extra-Wide Portable Wanigan Endwall — MK-18 Panel
993699	Portable Wanigan Door — MK-20 Panel
993700	Portable Wanigan Door — MK-21 Panel
993704	Extra-Wide Wanigan Roof — MK-11 Panel
993705	Extra-Wide Wanigan Roof — MK-12 Panel
993706	Extra-Wide Wanigan Roof — MK-13 Panel and MK-7 Gusset Plate
993707	Wanigan Accessories — Heating and Ventilating System

Y&D Number	Title
993708	Wanigan Accessories — Electrical Harness
993709	Wanigan Accessories — Side-Mounted Fuel Tank
	Special Drawings for the Pump Wanigan
993710	Fabrication Requirements
993711	Assembly
993712	MK-19 Panel
993713	MK-15 Panel
993714	Layout and Outfitting
993715	Outfitting

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